# KIBABII UNIVERSITY

## UNIVERSITY EXAMINATIONS
## 2021/2022 ACADEMIC YEAR

### SECOND YEAR FIRST SEMESTER
### MAIN EXAMINATIONS

### FOR THE DEGREE OF B.Sc. (CHEMISTRY)

**COURSE CODE:** **SCH 213**

**COURSE TITLE:** **BASIC CHEMICAL THERMODYNAMICS**

**DATE:** 25/01/2022 **TIME:** 8-10AM

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**INSTRUCTIONS TO CANDIDATES:**

TIME: 2 Hours

Answer **Question ONE** and **any TWO** of the remaining

**QUESTION ONE (30 Marks)**

(a) Define the following terms

i. Thermodynamics **(2Marks)**

ii. System **(2Marks)**

iii. Adiabatic process **(2Marks)**

iv. Isochoric process **(2Marks)**

(b) From the ideal gas equation $pv = nRT$, deduce Vander Waal equation of state **(3Marks)**

(c) Using the information given in equations *a, b,* and *c* below, calculate the enthalpy of the following reaction **(3Marks)**

$2C + 2H_3 \rightarrow C_2H_6$ ??kJ/mol

$C + O_2 \rightarrow CO_2\ \Delta H = -393.50kJ/mol$ ..... (a)

$H_2 + ½O_2 \rightarrow H_2O\ \Delta H = -241.84kJ$ ..... (b)

$C_2H_6 + \frac{7}{2}O_2 \rightarrow 2CO_2 + 3H_2O = -1267.3kJ/mol$ ..... (c)

(d)(i) Define heat capacity **(2Marks)**

(ii) Starting with $E = q - W$, show that the heat capacity at constant volume is given by $C_v = (\frac{dE}{dT})$ **(3Marks)**

(e) (i) State the Carnot theorem **(2Marks)**

(ii) Calculate the minimum amount of heat that must be withdrawn from hot reservoir at 137°C to obtain work equivalent to 15kJ per circle. The temperature of the sink=17°C **(4Marks)**

(f) (i) What is a spontaneous process **(2Marks)**

(ii) State any three examples of physical and chemical properties that can be used to explore the idea of spontaneity **(3Marks)**

**QUESTION TWO (20 marks)**

(a) Calculate the standard Gibbs free energy for the reaction at 25°C **(5Marks)**

$C_{(s)} + O_{2\,(g)} \rightarrow CO_{2\,(g)}$

$(\Delta H^o = -393.4kJmol^{-1}, \Delta S = 2.9jK^{-1})$

(b) (i) State the third law of thermodynamics **(2Marks)**

(ii) Define the term entropy **(2Marks)**

(iii) Using the information given below, calculate the entropy of the reaction $2NiS_{(s)} + 3O_{2\,(g)} \rightarrow 2SO_{2\,(g)} + 2NiO_{(s)}$ at 25°C **(6Marks)**

| | $S^\theta jK^{-1}mol$ |
|---|---|
| $SO_2$ | 248 |
| $NiO$ | 38 |
| $NiS$ | 53 |
| $O_2$ | 205 |

(c) (i) What is a state function **(2Marks)**

(ii) State any three examples of state functions **(3Marks)**

**QUESTION THREE (20 marks)**

**(a)** (i) Using $E = q - W$, show that heat of an isothermal reversible process is

$q = nRTln\frac{V_2}{V_1}$ **(5Marks)**

(ii) 2 $dm^3$ of hydrogen initially at stp are expanded isothermally to a volume of $4dm^3$. Calculate work done assuming ideal behaviour of hydrogen **(5Marks)**

(b) Using kinetic theory show that $C_v = \frac{3}{2}R$ **(5Marks)**

(c) (i) Define heat engine **(2Marks)**

(ii) Show that efficiency of a machine ($\eta$) is given by $\eta = 1 - \frac{T_2}{T_1}$ **(3Marks)**

**QUESTION FOUR (20 marks)**

(a) (i) State the second law of thermodynamics **(2Marks)**

(ii) Starting with $E = q - W$, Show that entropy change of a system when temperature and volume are variables is given by $\Delta S = \left[nC_v ln\frac{T_2}{T_1} + nRln\frac{V_2}{V_1}\right]$ **(10Marks)**

(iii) For one mole of a gas when temperature and volume are variables the entropy is given by;

$\Delta S = \left[C_v ln\frac{T_2}{T_1} + Rln\frac{V_2}{V_1}\right]$. Using this expression show that entropy of an isothermal process is

$\Delta S = \left[Rln\frac{P_1}{P_2} = Rln\frac{V_2}{V_1}\right]$ **(5Marks)**

(b) Distinguish between isobaric and isochoric processes **(3Marks)**

**QUESTION FIVE (20 marks)**

(a) Using the ideal gas equation. Derive and state the physical significance of gas constant R **(5 marks)**

b) Using the first law of thermodynamics ($dE = dq - pdv$), show that the specific heat capacity at constant pressure is given by $C_p = \left(\frac{dH}{dT}\right)$ **(10Marks)**

(c) Using kinetic theory, show that $C_p - C_v = 1$ **(5 marks)**